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13. ABSTRACT *(Maximum 200 words)*

This films and multilayers of functional ceramics have a number of important applications including dielectrics, magnetic recording media, piezoelectric transducers, and integrated optical devices. Variously functionalized self-assembled monolayers, attached to single-crystal silicon substrates, were used to direct the deposition of thin films of the oxides of titanium, zine, iron, and zirconium, at low temperatures and ambient pressures. The films were uniform, adherent, and pore-free and were, in many cases, comprised of micro-crystalline oxide particles. The monolayer functionality found to be most generally useful for these purposes included hydroxyl, carboxylate, and sulfonate functionality. In some cases the films contained desirable forms of the oxides that were different than those normally obtained i.e., the anatase form of titania as opposed to tutile; and the tetragonal form of zirconia as opposed to the monoclinic version. The patterning of the oxide films by patterning th underlying monolayer was also demonstrated. The project developed new technologies for the production of functional ceramics hy creating template for their deposition from solution and as such is a first step towards the generalized control of microstructural and crystallographic order by interface design in composite organic/inorganic materials.

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Final Technical Report for Air Force Office of Scientific Research

Fabrication of Functional Ceramic Composites
AFOSR AASERT Proposal (AFOSR #F49620-94-1-0334)
Project Period: July 1, 1994 - June 30, 1997

Departments of Chemistry and Materials Science and Engineering
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Abstract (100-200 words)

Thin films and multilayers of functional ceramics have a number of important applications including dielectrics, magnetic recording media, piezoelectric transducers, and integrated optical devices. Variously functionalized self-assembled monolayers, attached to single-crystal silicon substrates, were used to direct the deposition of thin films of the oxides of titanium,. zinc, iron, and zirconium, at low temperatures and ambient pressures. The films were uniform, adherent, and pore-free and were, in many cases, comprised of micro-crystalline oxide particles. The monolayer functionality found to be most generally useful for these purposes included hydroxyl, carboxylate, and sulfonate functionality. In some cases the films contained desirable forms of the oxides that were different than those normally obtained: i.e., the anatase form of titania as opposed to rutile; and the tetragonal form of zirconia as opposed to the monoclinic version. The patterning of the oxide films by patterning the underlying monolayer was also demonstrated. This project developed new technologies for the production of functional ceramics by creating templates for their deposition from solution and as such is a first step towards the generalized control of microstructural and crystallographic order by interface design in composite organic/inorganic materials.

Publications - Conference Proceedings

1. Mark R. De Guire, Hyunjung Shin, Rochael Collins, Monika Agarwal, Chaim N. Sukenik, and Arthur H. Heuer, "Deposition of Oxide Thin Films on Silicon Using Organic Self-Assembled Monolayers," in Integrated Optics and Microstructures III, Massood Tabib-Azar, ed. Proc. SPIE 2686, pp. 88-99 (1996).
2. Hyunjung Shin, Monika Agarwal, Mark R. De Guire, and Arthur H. Heuer, "Deposition Mechanism of Oxide Thin Films on Self-Assembled Organic Monolayers," Proceedings of the workshop on Synergistic Synthesis of Inorganic Materials, M. Rühle and F. Lange, eds. Acta Mater. (in press).
3. Mark R. De Guire, Thomas P. Niesen, Jurand Wolff, Sitthisuntorn Supothina, Joachim Bill, Fritz Aldinger, & Manfred Rühle, "Synthesis of Oxide and Non-oxide Inorganic Materials at Organic Surfaces," Proceedings of the workshop on Grain Boundary Dynamics of Precursor-Derived Covalent Ceramics. Schloss Ringberg, Germany, 10-14 November, 1996. F. Aldinger and J. Bill, eds. Wiley-VCH Verlagsgesellschaft mbH (submitted for publication).

Publications - Refereed Journals

1. Shin, R. J. Collins, M. R. De Guire, A. H. Heuer, and C. N. Sukenik, "Synthesis and Characterization of TiO_2 Thin Films on Organic Self-Assembled Monolayers: I. Film Formation from Aqueous Solutions," J. Mater. Res. 10 [3] 692-8 (1995).
2. Shin, R. J. Collins, M. R. De Guire, A. H. Heuer, and C. N. Sukenik, "Synthesis and Characterization of TiO_2 Thin Films on Organic Self-Assembled Monolayers: II. Film Formation via an Organometallic Route," J. Mater. Res. 10 [3] 699-703 (1995).
3. Rochael J. Collins, Hyunjung Shin, Mark R. De Guire, Arthur H. Heuer, and Chaim N. Sukenik, "Low Temperature Deposition of Patterned TiO_2 Thin Films Using Photopatterned Self-Assembled Monolayers," Appl. Phys. Lett. 69 [6] 860-2 (1996).
4. Hyunjung Shin, Monika Agarwal, Mark R. De Guire, and Arthur H. Heuer, "Solid State Diffusive Amorphization in TiO_2/ZrO_2 Bilayers," J. Am. Ceram. Soc. 79 [7] 1975-8 (1996).
5. Collins, R.J. and Sukenik, C.N. "Sulfonate-Functionalized, Siloxane-Anchored, Self-Assembled Monolayers", Langmuir 11, 2322-2324 (1995).
6. Collins, R.J.; Bae, I.T.; Scherson, D.A.; and Sukenik, C.N. "Photocontrolled Formation of Hydroxyl-Bearing Monolayers and Multilayers", Langmuir 12, 5509-5511 (1996).
7. Monika Agarwal, Mark R. De Guire, and Arthur H. Heuer, "Synthesis of ZrO_2 and Y_2O_3-doped ZrO_2 Thin Films Using Self-Assembled Monolayers" J. Am. Ceram. Soc. (accepted for publication).
8. Monika Agarwal, Mark R. De Guire, and Arthur H. Heuer, "Synthesis of Yttrium Oxide Thin Films With and Without the Use of Organic Self-Assembled Monolayers," Appl. Phys. Lett. (in press).
9. Hyunjung Shin, Mark R. De Guire, and Arthur H. Heuer, "Electrical Properties of TiO_2 Thin Films Formed on Self-Assembled Organic Monolayers on Silicon," submitted to J. Appl. Phys.

Patents

1. Mark R. De Guire, Chaim N. Sukenik, and Arthur H. Heuer, "Synthesis of Metal Oxide Thin Films," U.S. Patent No. 5,352,485, issued 4 October 1994.
2. Mark R. De Guire, Chaim N. Sukenik, and Arthur H. Heuer, "Synthesis of Metal Oxide Thin Films," U.S. Patent No. 5,545,432, issued 13 August 1996 (Continuation in part of U.S. Patent No. 5,352,485.)

Doctoral Theses (completed or in progress)

1. Hyun-Jung Shin, "Deposition Mechanisms and Electrical Properties of TiO_2 Thin Films on Self-Assembled Organic Monolayers on Si," August 1996.
2. Monika Agarwal, "Low Temperature Synthesis of Zirconia Thin Films," August 1996.
3. Rochael J. Collins, "Functionalized Self-Assembled Monolayers as Templates for Mineral Oxide Thin Film Deposition," January 1997.
4. Sitthisuntorn Supothina, "Synthesis of Functional Ceramic Coatings on Ceramic Powders Using Organic Self-Assembled Monolayers," December 1998 (expected).

Master's Theses

1. Hyunjung Shin, "Synthesis of TiO_2 Films on Self-Assembled Organic Monolayers on Silicon," May 1994.
2. Mou Maiti, "Synthesis of Iron Oxide Thin Films on Organic Templates on Silicon," August 1994.
3. Sitthisuntorn Supothina, "Deposition of ZnO Thin Films on Self-Assembled Organic Monolayers on Silicon," January 1996.

Senior Undergraduate Theses

1. Charles Baldwin, "The Deposition of Monolayer Coatings on Surgical Steel", May 1996
2. Jeffrey Pfefferkorn, "Synthesis and Characterization of Self Assembled Monolayers Containing Activated Esters", May 1997

AASERT 97

AUGMENTATION AWARDS FOR SCIENCE & ENGINEERING RESEARCH TRAINING (AASERT) REPORTING FORM

The Department of Defense (DoD) requires certain information to evaluate the effectiveness of the AASERT Program. By accepting this Grant which bestows the AASERT funds, the Grantee agrees to provide 1) a brief (not to exceed one page) narrative technical report of the research training activities of the AASERT-funded student(s) and 2) the information requested below. This information should be provided to the Government's technical point of contact by each annual anniversary of the AASERT award date.

1. Grantee identification data: (R&T and Grant numbers found on Page 1 of Grant)

a. Case Western Reserve University
University Name

b. AFOSR#F49620-94-1-0334
Grant Number

c. N/A
R&T Number

d. Chaim N. Sukenik
P.I. Name

e. From: July 1, 1996 To: June 30, 1997
AASERT Reporting Period

NOTE: Grant to which AASERT award is attached is referred to hereafter as "Parent Agreement".

2. Total funding of the Parent Agreement and the number of full-time equivalent graduate students (FTEGS) supported by the Parent Agreement during the 12-month period prior to the AASERT award date.

a. Funding: $318,275

b. Number FTEGS: 2

3. Total funding of the Parent Agreement and the number of FTEGS supported by the Parent Agreement during the current 12-month reporting period.

a. Funding: $0

b. Number FTEGS: 0

4. Total AASERT funding and the number of FTEGS and undergraduate students (UGS) supported by AASERT funds during the current 12-month reporting period.

a. Funding: $ 222,355

b. Number FTEGS: 1

c. Number UGS: 1

VERIFICATION STATEMENT: I hereby verify that all students supported by the AASERT award are U.S. citizens or a native resident of a possession of the United States such as American Samoa. It does not refer to a citizen of another country who has applied for US citizenship or to permanent residents of the United States.

Chaim N. Sukenik
Principal Investigator

1-10-97
Date